"Any citizen who graduates from a liberal arts college who is not familiar with computer usage is being educationally cheated. We believe this same statement can be applied to the secondary school student today."

EXCERPTS FROM THE RESEARCH
AND DEVELOPMENT REPORT
EAST ISLIP HIGH SCHOOL
COMPUTER MATHEMATICS PROGRAM

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The most common subject taught around computers -- besides data processing itself -- is mathematics. Experiments have shown that teaching students to program a computer and then requiring them to solve problems with it is effective in improving thier problem-solving abilities. The success of this technique has been attributed to the need for precise, detailed, step-by-step procedures in computer usage.

DIFFERENT APPROACHES TO COMPUTER MATHEMATICS EDUCATION

I. Transporting Materials to a Computer Center:

One means of a student having access to a computer is to have a computer located remotely from the student, and have materials transported to and from the computer center. This can be accomplished by courier or by mail.

The delay in running programs inherent in such a system is disadvatageous in many respects. The delay itself in obtaining results is an inconvenience. More important is the interruption of the logical thinking and orderly reasoning behind the writing of a computer program. The interest, insight and motivation factors will all experience extremes evidenced by many peaks and valleys. Many students, in having a program returned with errors, will have lost contact with the intimate line of reasoning that went into the organized program. Instead of finding and correcting an error (debugging) in his program it would mean an almost complete duplication of his initial effort. He was not able to utilize the computer itself to check his program in various stages of its progress.

While the biggest advantage of such a system is its slightly lower cost factor, this is more than offset by the tremendous technological improvements over the last ten years which have brought the costs of more improved computers, down to the level where they are feasible for use in a school system.

II. Transporting Students to a Computer Center:

Another means of granting access of a student to a computer is to transport the student himself to the computer.

While this method does provide for invaluable "hands on" experience for the student, it presents tremendous difficulties in scheduling and providing transportation for students.

First, the computer must be made available at certain times. During these free periods, the students must also be available. Thirdly, transportation must also be available at this same time.

Add to this the increased cost of transportation itself, the limited amount of time on the computer that will be made available to each student, and the factors against heavily outweigh the factors for such an endeavor.

III. Remote Terminal - Time Shared Computer:

Those in favor of a time sharing plan for computer usage, propose the following arguments in favor of their plan:

1. Hardware is always the latest.
2. Software is always the latest.
3. There is no need to worry about breadown.
4. It is more economical.

We would offer the following counter-arguments in favor of purchasing an on-hand computer as opposed to utilizing a time sharing remote terminal plan:

1. Hardware is always the latest.

In addition to the comments concerning hardware in part 1 of this rebuttal, we submit the following:

The computer we recommend, the PDP-8/I has most of the features of most of the high priced computers on the market today. It has expandability features that include 32K words of core storage, over 1 million words of disk storage, over 1.5 million words with DECtape, tape readers and punches, magnetic tape, IBM magnetic tape, line printer, converters, cathode ray tube displays, increment plotter, oscilloscope displays, photomultiplier light pens, etc.

This system is one that offers the 'most of the best for the least'. We do not fear any changes in hardware that may come about. This hardware will continue to be functional, practical and economical for many years to come.

The proposed configuration can be expanded very easily and economically to become the nucleus of an internal time shared system. We could do what a time shared system could do, with terminals in classrooms and offices for much less than a time shared system commercially offered (see part 5 of this narrative).

We will stand behind this hardware.

2. Software is always the latest.

Software is another one of the strong points in the system we endorse. We couldn't ask for more than a keyboard monitor system; PAL III, a basic assembler; MACRO-8, an advanced symbolic assembler; a 4K and an 8K FORTRAN compiler; symbolic tape editor; floating point package; mathematical function subroutines; utility and maintenance programs; BASIC and Digital's own FOCAL conversational language.

Software doesn't necessarily become obsolete. It is rewritten and updated. New techniques, routines and programs are constantly being developed, field tested and documented through the Digital Program Library and DECUS, Digital Equipment Corporation Users Society.

The software that will become available to use will be among the very best for this type of computer.

3. There is no need to worry about breakdown.

We will be just as concerned about down-time as the next computer user. As for a remote terminal, if it becomes inoperative, they must wait for repairs or replacement just as we would (discounting an off-line stand by unit which we propose). If there is a malfunction in the computer itself, a terminal user is notified, at varying intervals of time, that his service is being shifted to another computer. Often this is another more remotely located computer and all storage, programs, data, etc. is lost until you are once again returned to the original computer. It would be like starting a course all over again.

A breakdown is nothing to look forward to in any system. The best one can do is to obtain reliable equipment to initiate the program (we intend to) and to have quick, efficient, local service available.

4. It is more economical.

Is it really more economical? Figures, charges, charts, graphs, and statistics are flaunted about and the claim is made that it is more economical than purchase. If one were to expend hundreds of thousands of dollars, this may be a valid claim. For what we propose, we maintain that remote terminals would be more expensive.

The best way to determine the validity of charges and countercharges regarding costs of time-sharing, is to go right to such a typical installation and observe, investigate and compare. This was done.

At one high school, the cost of the system was almost double what they had anticipated. Our program, being at least as ambitious as the one in operation at the high school, would cost a minimum of $1,000 per month. This would be increased by one of the biggest portions of the charge, the line charge which is based on the number of miles from computer to terminal and the number of terminals. Since we are much further from New York City than they are, the charge, which is approximately $15 per mile per terminal per month, would be much greater to start.

Our final comments would concern themselves with the fact that the cost of time-sharing is directly proportional to the number of programs run, which in turn is a function of the number of students involved. We would be in the position of hesitating to ask our students to become more efficient, or to expand the program to include more students because "we couldn't afford it".

Under our proposed system, we could double, even quadruple the number of programs and increase our cost only a few cents per day for a few more sheets of paper and a few cents worth of electricity.

We feel that over a period of time, our system will prove to be more economical, even with our own version of a time shared system with terminals in different locations and in different schools.

IV. On Hand Computer:

Our overall goals are two-fold. We intend to use a computer as an area of study as well as using it to assist in problem solving in any or all phases of our curriculum. As described elsewhere, the computer is to be both a tool and an object of education. We feel that in order to fulfill these objectives, a student must have actual hands-on experience. Each student involved in a computer course should be able to actually run his own program, from the problem being posed to its successful solution. This would involve the student in the following procedures:

1. Presentation of the problem.
2. Analysis of the problem.
3. Constructing a flow chart of the program.
4. Writing the program.
5. Preparing the program for entry to the computer by
    (a) marked cards
    (b) punched tape
6. Entering the program into the computer by
    (a) optical mark reader
    (b) high speed tape reader
    (c) direct entry on the console
7. Possible debugging of program at this stage.
8. Running of the program.
9. Possible debugging of program at this stage.
10. Rerunning the program if needed.
11. Obtaining print out of results
    (a) on teletypewriter print out
    (b) on tape for off-line print out
12. Analysis of problem and results.

In this manner and only in this manner, will a student be able to effectively attain both of the major objectives as set forth in this proposal.

Not too many years ago, we would have been faced with a decision concerning eitherone of two different alternatives:

1) Should we choose a small computer in order to have actual hands on experience even though it had very limited capabilities in problem solving,

OR

2) Should we enroll in a time-sharing plan that would give students little opportunity for hands-on operation but would provide tremendous problem solving potential?

Fortunately, we are now able to combine both of these features, the goals we have in mind, into one system, the one we have recommended.

Any other method that may be considered would be too time consuming to be readily available, too expensive to be really practical or too spasmodic to be truly effective.

We maintain that with the recent advent of the Digital PDP-8/I general purpose computer, small but expandable, powerful but inexpensive, the best possible computer program that we could offer to our school district would be one based on the purchase of the configuration built around this computer.